ima 36, to which significant frequency lines ~~38~~ are assigned, are determined for these determined frequency ranges 34.

According to the method shown in fig. 2, a synthetic spectrum 42 is determined in a spectrum calculation unit 40 based on the frequency lines ~~38~~ determined in the frequency line module 20 and supplied to a spectral synthesis 44.

Since the spectral synthesis 44 reverses the processes of the DEMON-analysis 10, this spectral synthesis 44 will also be referred to as DEMON-synthesis 44 in the following.

In the DEMON-synthesis 44, the synthetic spectrum 42 is first transformed into the time domain in a synthesis device 46, wherein analysis parameter values 48 from the DEMON-analysis 10 can be taken into account.

Among the analysis parameters 48 are e.g. the used window width and window form for singling out a finite time sequence of the signal to be transformed, the used sampling frequency and/or the used number of samples. The transformation then preferably takes place by means of an inverse complex discrete Fourier transform, more specifically by means of an inverse fast Fourier transform (IFFT). A synthetic time signal 50 is thus generated, which is supplied to a modulation module 52 according to the DEMON-synthesis 44.

According to the invention, a carrier module 54 provides a carrier signal 56 to the method, the selection of the carrier signal 56 being carried out manually by the operator or automatically.

By means of an amplitude modulation, an amplitude-modulated, acoustic signal 58, which contains the basic characteristics of the original signal, is generated in accordance with the DEMON-synthesis 44 in the modulation module 52 based on the synthetic time signal 50 and the carrier signal 56. This signal is acoustically issued to the operator preferably via headphones or speakers.

Fig. 4 shows an exemplary amplitude-modulated, acoustic signal 58 as generated by the DEMON-synthesis 44. Here, the time is plotted in seconds on a horizontal axis 60 and the amplitude of the signal 58 on a vertical axis 62. This exemplary representation shows the result of the synthesis of the first detected frequency line from fig. 3.

In order to potentially provide the operator with a better auditory impression, different parameters can be varied in the method for processing the underwater sound signals.

The DEMON-spectrum 18 can be preferably stored by means of a storage module 68, in order to generate different synthetic spectra 42 as well as different synthetic time signals 50 based on this frequency spectrum 18 from the DEMON-analysis 10.

By determining several different threshold values 22 within the threshold value module 24, several synthetic spectra 42 with a respectively different threshold value 22, for example, can be generated based on the DEMON-spectrum 18. Thereby, several targets become distinguishable because the volumes of the operating noises of the targets may be different due to different distances and thus the levels or amplitudes of significant frequency ranges 34 of the DEMON-spectrum 18 may be different. The threshold values 22 can be modified manually by the operator or automatically at any time during the process.

Another modifiable parameter in the method for processing underwater sound signals is the selection of individual frequency lines ~~38~~ within the frequency line module 20. These frequency lines ~~38~~ can be faded in or out in a targeted manner for calculating the synthetic spectrum 42. This takes place e.g. by setting the frequency amplitude value of the frequency to be faded out or in to a value below or above the determined threshold value 22. Furthermore, it is conceivable to add additional frequency lines for calculating the synthetic spectrum 42.

An optional expansion of the invention provides comparing the frequency lines ~~38~~ of the DEMON-spectrum 18 with known frequency line patterns that are stored in a database.

Fig. 5 shows a block diagram of such an expansion of the method for processing underwater sound signals. Here, the previously described method is expanded to include a comparison module 70 with a database.

The DEMON-spectra 18 are transferred by the DEMON-analysis to the frequency module 20, which determines significant frequency lines ~~38~~ in the DEMON-spectrum 18 by means of a first threshold value 22. Based on this, the spectrum calculation unit 40 forms a synthetic spectrum 42 that is transferred to the comparison module 70.

The comparison module 70 has a database in which frequency line patterns of known DEMON spectra are stored, based on which known vehicles can be classified or identified. When comparing the synthetic spectrum 42 to the frequency line patterns of the database, the target speed of the sound source is taken into account, since a moving target causes speed-dependent spreads in the frequency line pattern. The comparison module 70 therefore has means for taking into account the speed of the target and, if necessary, for calculating a normalized synthetic spectrum 42, which is compared with the frequency line patterns of the database. The comparison module 70 is furthermore preferably configured in such a manner that it considers the variations of the characteristic spectrum caused by changes in the rotational speed.

Fig. 6 shows an explanation of the operation of the comparison module 70. If a frequency line pattern, that comes closest to the frequency lines ~~38~~ of the DEMON-spectrum, is recognized in a decision block 72 during a comparison of the synthetic spectrum 42 with known frequency line patterns of a database, a difference unit 76 is actuated via the branch 74. This unit generates a synthetic residual spectrum 78 by extracting the frequency line ~~38~~ that corresponds to the frequency line pattern from the synthetic spectrum 42. A spectrum pattern 80 is

generated based on the extracted frequency lines ~~38~~ by means of the difference unit 76.

As shown in fig. 5, the residual spectrum 78 is transferred to the frequency line module 20, which identifies frequency lines ~~38~~ in the residual spectrum 78 based on the first or another threshold value 22, from which another synthetic spectrum 42 is generated. This synthetic spectrum 42 is also transferred to the comparison module 70 and the method is again implemented as described above by means of fig. 5.

However, if no frequency line pattern of the database is recognized in the DEMON-spectrum 18, the synthetic spectrum is transferred by the decision block 72 via a branch 82 to the DEMON-synthesis according to the method described above.

In this manner, depending on the number of recognized sound signatures, up to N different spectrum patterns 80_1 to 80_N as well as a synthetic spectrum 42 of the residual signal are generated, which are transferred to the DEMON-synthesis 44. The DEMON-synthesis 44 generates respectively one synthetic amplitude-modulated time signal for the spectrum patterns 80 and the synthetic spectrum 42 of the residual signal, which is separately issued acoustically to the operator in order to allow for an acoustic separation of targets with the same bearing.

Another modifiable parameter for processing underwater sound signals is the carrier signal 56 provided by the carrier module 54 and used during modulation of the synthetic time signal 50. Thus, it is possible to generate different synthetic amplitude-modulated acoustic signals 58 for one and the same synthetic time signal 50 and to issue them to the operator. Playing back the differently processed audio signals 58 makes it possible for the operator to choose the best sound result or to choose the best auditory impression of the selected signature.

Another modifiable parameter of the method according to the invention is a ratio between the amplitude change of the modulated carrier wave and the amplitude

Claims

1. A method for processing underwater sound signals, ~~more specifically~~which are amplitude-modulated broadband sounds, which are radiated or emitted by vehicles, the broadband sounds being received as acoustic signals by means of a sonar device (2) and being subjected to a spectral analysis (10), ~~more specifically~~which is a Detection Envelope Modulation On Noise, DEMON- analysis (10), which generates corresponding frequency spectra (18) based on the acoustic signals (8),
characterized in that
at least one local maximum (36) is determined within the frequency spectrum (18) or within a spectrum derived from the frequency spectrum (18) by means of at least one predetermined threshold value (22), the local maximum or local maxima (36) corresponding to individual frequency lines ~~(38)~~ of the spectrum (18),
a synthetic spectrum (42) is generated by means of the determined frequency lines ~~(38)~~ and is subjected to a spectral synthesis (44), ~~more specifically a DEMON-synthesis (44)~~,
a corresponding synthetic time signal (50) is generated and a synthetic amplitude-modulated signal (58) is generated based on the synthetic time signal (50) and a carrier signal (56) by means of the spectral synthesis (44).

2. The method according to claim 1,
characterized in that
in order to generate the synthetic spectrum (42), one, several or all determined frequency lines ~~(38)~~ are selected and/or additional frequency lines are added.

3. The method according to claim 1 or 2,
characterized in that
the method additionally features the following steps:

a) comparison of the synthetic spectrum (42) with known frequency line patterns of a database and

b) i) if at least one frequency line pattern in the synthetic spectrum (42) is recognized:

generation of a synthetic residual spectrum (78) by extracting that determined frequency line ~~(38)~~ from the synthetic spectrum (42) which corresponds to the frequency line pattern,

generation of a synthetic spectrum pattern (80) from the extracted frequency lines ~~(38)~~, which is transferred to spectral synthesis (44) and

continuation of the method with step a), wherein the residual spectrum (78) corresponds to a new synthetic spectrum (42).

ii) if no frequency line pattern in the synthetic spectrum (42) is recognized:

transfer of the synthetic spectrum (42) to spectral synthesis (44).

4. The method according to one of the afore-mentioned claims, characterized in that

a carrier signal (56) is selected from a multitude of available carrier signals and is used with the synthetic time signal (50) for modulation.

5. The method according to one of the afore-mentioned claims, characterized in that

the frequency spectrum (18) generated by spectral analysis (10) is stored and

one or several different synthetic spectra (42) are generated based on this frequency spectrum (18) by varying setting parameters and one or several synthetic time signals (50) are generated based on the synthetic spectra (42).

6. The method according to one of the afore-mentioned claims, characterized in that

the synthetic spectrum (42) is transformed from the frequency domain into the time domain by means of an inverse complex discrete Fourier transform, more specifically by means of an inverse fast Fourier transform.

7. The method according to one of the afore-mentioned claims,
characterized in that
the synthetic amplitude-modulated signal (58) is output via a sound reproduction system, more specifically headphones and/or a speaker.

8. A device for processing underwater sound signals, ~~more specifically~~which are amplitude-modulated broadband sounds, which are radiatable or emittable by vehicles, the broadband sounds being receivable as acoustic signals by means of a sonar device (2) and being subjectable to a spectral analysis (10), which is a Detection Envelope Modulation On Noise ~~more specifically a~~ DEMON~~-~~ analysis (10), the spectral analysis (10) being designed so as to generated corresponding frequency spectra (18) based on the acoustic signals (8),
characterized by
a threshold value module (24), which is designed so as to define at least one threshold value (22),
a frequency line module (20), which is designed so as to determine at least one local maximum (36) within the frequency spectrum (18) or within a spectrum derived from the frequency spectrum by means of the predetermined threshold value (22), the local maximum or local maxima (36) corresponding to the individual frequency lines ~~(38)~~,
a spectrum calculation unit (40), which is designed so as to generate a synthetic spectrum (42) by means of the determined frequency lines ~~(38)~~, the synthetic spectrum (42) being subjectable to a spectral synthesis (44), ~~more specifically a DEMON-synthesis (44),~~
a synthesis device (56), which is designed so as to generate a corresponding synthetic time signal (50) from the synthetic spectrum (42) in accordance to the spectral synthesis (44) and

a modulation module (52), which is designed so as to generate a synthetic amplitude-modulated signal (58) from the synthetic time signal (50) and from a carrier signal (56) provided by a carrier module (54) in accordance with the spectral synthesis (44).

9 The device according to claim 8,
characterized by
a further development of the frequency line module (20) so as to select one, several or all determined frequency lines ~~(38)~~ and/or to add additional frequency lines for generating the synthetic spectrum (42).

10 The device according to claims 8 to 9,
characterized by
a database with known frequency line patterns,
a comparison module (70), which is designed so as to compare the synthetic spectrum (42) with known frequency line patterns,
a difference unit (76), which is designed so as to generate a synthetic residual spectrum (78) by extracting such determined frequency lines ~~(38)~~ from the synthetic spectrum (42) as correspond to the frequency line pattern,
a further development of the difference unit (76) so as to generate a synthetic spectrum pattern (80) from the extracted frequency lines and to transfer it to the synthesis device (46).

11. The device according to one of the claims 8 to 10,
characterized by
a carrier module (54), which is designed so as to choose a carrier signal (56) from a multitude of available carrier signals, which is usable for modulation with the synthetic time signal (50).

12. The device according to one of the claims 8 to 11,
characterized by

a storage module (68), which is designed so as to store the frequency spectrum (18) generated by the spectral analysis (10) and

means for generating one or several different synthetic spectra (42) from the stored frequency spectrum (18), based on which one or several synthetic time signals (50) are generatable.

13. The device according to one of the claims 8 to 12,

characterized by

a design of the synthesis device (46) with means for transforming the synthetic spectrum (42) from the frequency domain into the time domain by means of an inverse complex discrete Fourier transform, more specifically an inverse fast Fourier transform.

14~~13~~. The device according to one of the claims 8 to 13,

characterized by

a sound reproduction system, more specifically headphones and/or speakers, which are designed so as to issue the synthetic amplitude-modulated signal (58).